DOCUMENT RESUME

ED 404 119 SE 054 721

TITLE	The Living Ocean.
INSTITUTION	National Aeronautics and Space Administration, Washington, D.C.
REPORT NO	NASA-EP-307
PUB DATE	Jan 94
NOTE	9p.
AVAILABLE FROM	NASA Teacher Resource Center, Mail Stop 8-1, NASA Lewis Research Center, 2100 Brookpark Road, Cleveland, OH 44135.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Environmental Education; Grade 9; Grade 10; *Greenhouse Effect; High Schools; *Oceanography; *Photosynthesis; Science Education; Teaching Guides
IDENTIFIERS	Atmospheres; *Carbon Dioxide; *Phytoplankton

ABSTRACT

This teaching guide contains information, activities, and discussion questions and answers about oceans for grades nine and ten. The information section covers the following topics: studying global ocean color from space, what can be seen from space, phytoplankton, carbon dioxide, and the greenhouse effect of the earth. (MKR)

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ED 404 119

Educational Product
Teachers | Grades 9-10

THE LIVING OCEAN

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SeaWiFS: Studying Ocean Color From Space

Teacher's Guide with Activities

NASA
National Aeronautics and Space Administration
Office of Mission to Planet Earth
Education Office

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Life in the Oceans: Studying Global Ocean Color from Space

Covering about seventy percent of the Earth's surface, the oceans are central to the continued existence of life on our planet. The oceans are where life first appeared on Earth. The largest creatures on Earth (whales) and the smallest (bacteria and viruses) live in the oceans. We rely on the ocean for many things, including food, water, transportation, recreation, minerals, and energy. Oceans store energy. When ocean currents change, they cause changes in global weather patterns and can cause droughts, floods, and storms.

However, our knowledge of our oceans is limited. Ships, coastlines, and islands provide places from which we can observe, sample, and study small portions of oceans. But we can only look at a very small part of the global ocean this way. We need a better place from which to study oceans.

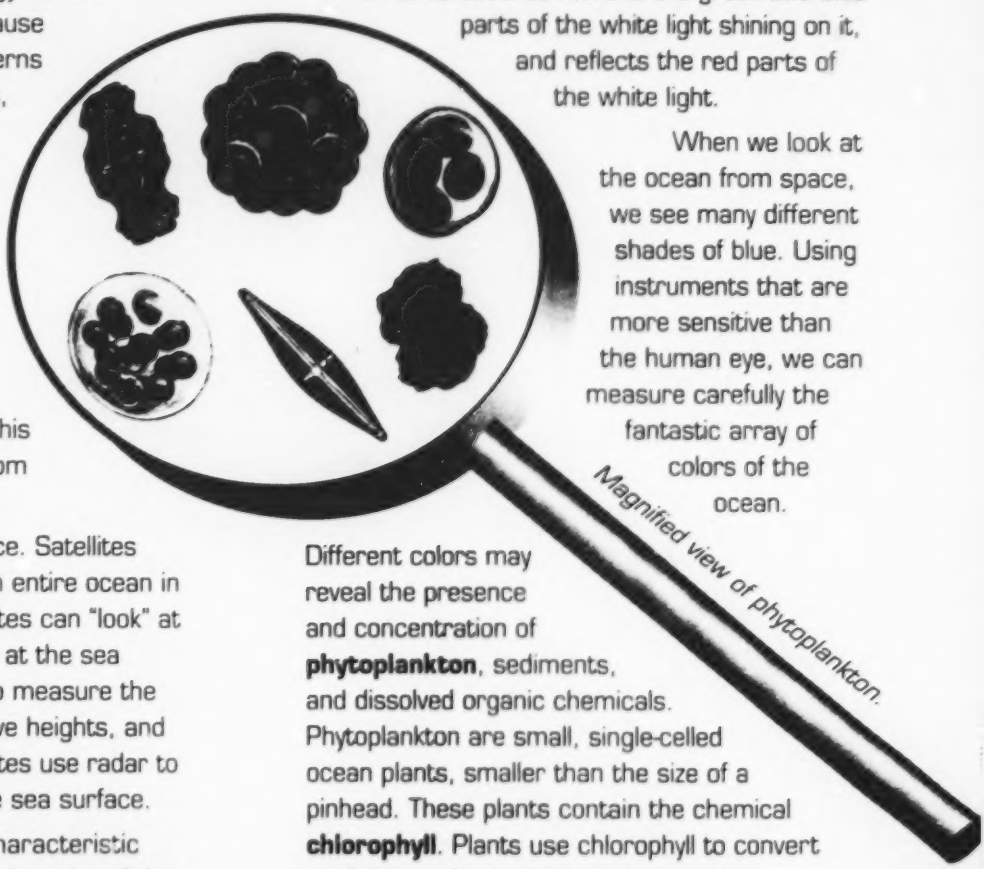
Space provides this place. Satellites circling the Earth can survey an entire ocean in less than an hour. These satellites can "look" at clouds to study the weather, or at the sea surface (when it's not cloudy) to measure the sea's surface temperature, wave heights, and direction of waves. Some satellites use radar to "look" through the clouds at the sea surface.

One other important characteristic that we can see from space is the color of the ocean. Changes in the color of ocean water over time or across a distance on the surface provide valuable information.

The Ocean Isn't Just Blue: What We See from Space

We see color when light is reflected by objects around us. White light is made up of a **spectrum** or combination of colors, as in a rainbow. When light hits the surface of an object, these different colors can be reflected or absorbed in differing intensities. The color we see depends on which colors are reflected and which are absorbed. For example, a book that appears red to us absorbs more of the green and blue parts of the white light shining on it, and reflects the red parts of the white light.

When we look at the ocean from space, we see many different shades of blue. Using instruments that are more sensitive than the human eye, we can measure carefully the fantastic array of colors of the ocean.



Magnified view of phytoplankton.

Different colors may reveal the presence and concentration of **phytoplankton**, sediments, and dissolved organic chemicals. Phytoplankton are small, single-celled ocean plants, smaller than the size of a pinhead. These plants contain the chemical **chlorophyll**. Plants use chlorophyll to convert sunlight into food using a process called **photosynthesis**. Because different types of phytoplankton have different concentrations of chlorophyll, they appear as different colors

to sensitive satellite instruments such as the Sea-viewing Wide Field-of-View Sensor (SeaWiFS). Thus, looking at the color of an area of the ocean allows us to estimate the amount and general type of phytoplankton in that area, and tells us about the health and chemistry of the ocean. Comparing images taken at different periods tells us about changes that occur over time.

In addition, the plants show where pollutants poison the ocean and prevent plant growth, and where subtle changes in the climate—warmer or colder, more saline or less saline—affect phytoplankton growth. Since phytoplankton depend upon specific conditions for growth, they frequently become the first indicator of a change in their environment.

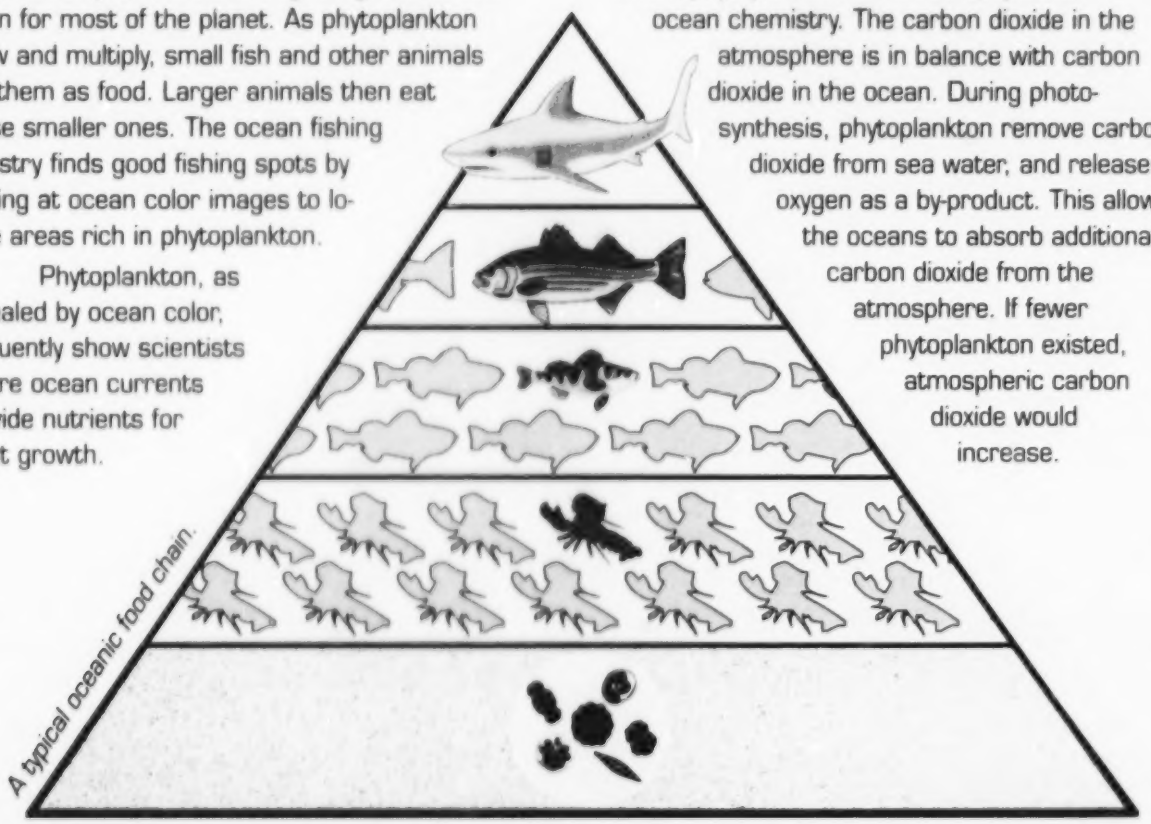
Phytoplankton: A Little Link in a Big Chain

Why are phytoplankton so important? These small plants are the beginning of the food chain for most of the planet. As phytoplankton grow and multiply, small fish and other animals eat them as food. Larger animals then eat these smaller ones. The ocean fishing industry finds good fishing spots by looking at ocean color images to locate areas rich in phytoplankton.

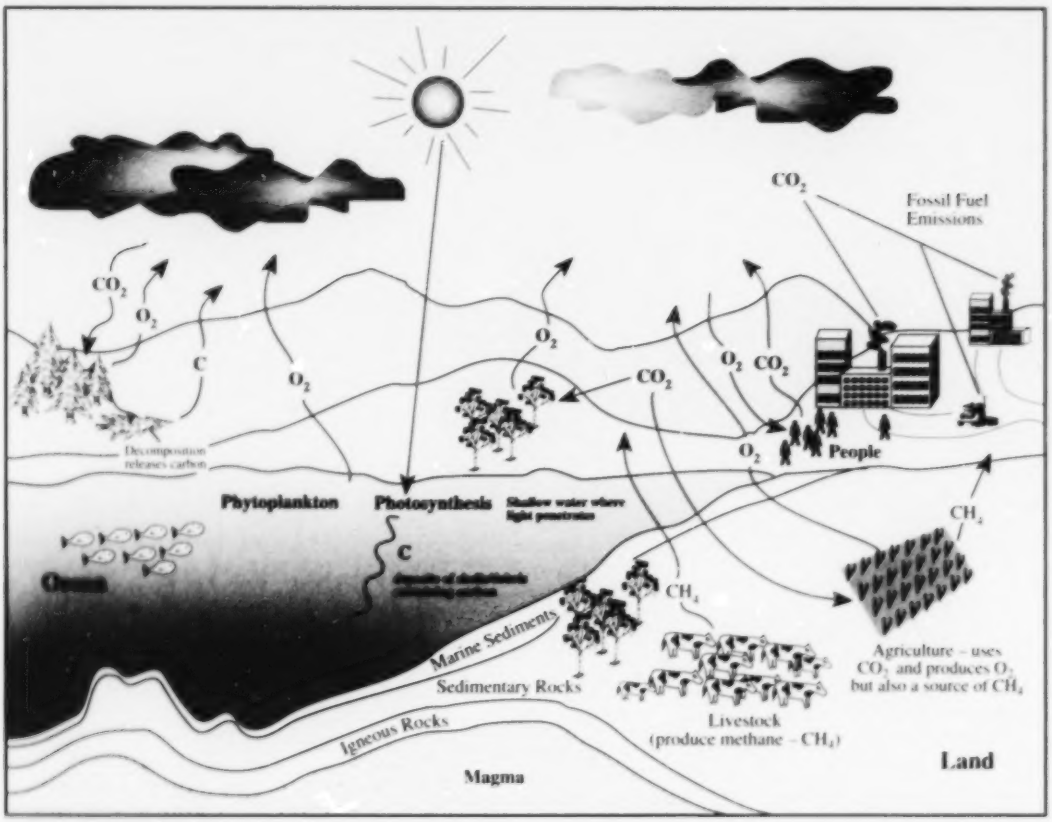
Phytoplankton, as revealed by ocean color, frequently show scientists where ocean currents provide nutrients for plant growth.

Carbon: Where Does It All Go?

Besides acting as the first link in the food chain, phytoplankton are a critical part of ocean chemistry. The carbon dioxide in the atmosphere is in balance with carbon dioxide in the ocean. During photosynthesis, phytoplankton remove carbon dioxide from sea water, and release oxygen as a by-product. This allows the oceans to absorb additional carbon dioxide from the atmosphere. If fewer phytoplankton existed, atmospheric carbon dioxide would increase.



A typical oceanic food chain.



The carbon cycle.

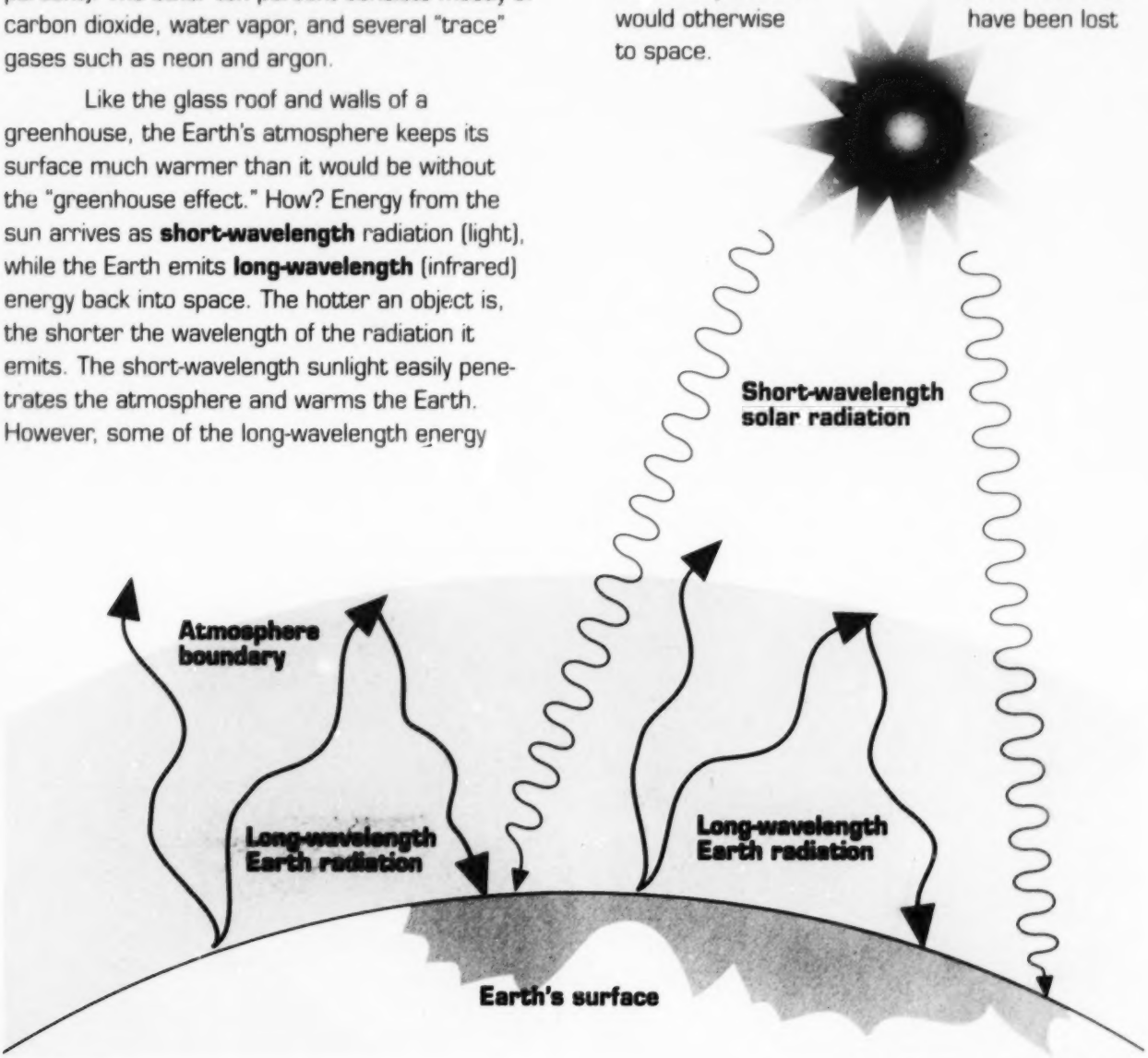
Phytoplankton also affect carbon dioxide levels when they die. Phytoplankton, like plants on land, are composed of substances that contain carbon. Dead phytoplankton can sink to the ocean floor. The carbon in the phytoplankton is soon covered by other material sinking to the ocean bottom. In this way, the oceans act as a **sink**, a place to dispose of global carbon, which otherwise would accumulate in the atmosphere as carbon dioxide. Other global sinks include land vegetation and soil. However, the carbon in these sinks frequently is returned to the atmosphere as carbon dioxide by burning or decomposition. Deforestation contributes to the accumulation of carbon dioxide in the atmosphere by reducing vegetation that takes up carbon dioxide. Carbon dioxide acts as a "greenhouse" gas in the atmosphere, and therefore may contribute to global warming. Sources of carbon dioxide in the Earth's atmosphere include decomposition of organic matter (such as trees), the carbon dioxide that animals and people exhale, volcanic activity, and human activities such as the burning of fossil fuels and wood.

No one yet knows how much carbon the oceans and land can absorb. Nor do we know how the Earth's environment will adjust to increasing amounts of carbon dioxide in the atmosphere. Studying the distribution and changes in global phytoplankton using ocean color and other tools will help scientists find answers to these questions.

The Earth: A Giant Greenhouse

The Earth is unique to our solar system: it can sustain life. Without the Earth's atmosphere, our planet would become extremely cold and barren of life. The atmosphere consists of nitrogen (about 70 percent) and oxygen (about 20 percent). The other ten percent consists mostly of carbon dioxide, water vapor, and several "trace" gases such as neon and argon.

Like the glass roof and walls of a greenhouse, the Earth's atmosphere keeps its surface much warmer than it would be without the "greenhouse effect." How? Energy from the sun arrives as **short-wavelength** radiation (light), while the Earth emits **long-wavelength** (infrared) energy back into space. The hotter an object is, the shorter the wavelength of the radiation it emits. The short-wavelength sunlight easily penetrates the atmosphere and warms the Earth. However, some of the long-wavelength energy emitted from the Earth is absorbed by the atmosphere before it escapes into space. Carbon dioxide, water vapor, and other gases in the atmosphere are responsible for absorbing escaping long-wavelength energy. Thus, the Earth keeps some of the heat that would otherwise have been lost to space.



The greenhouse effect.

The concentration of carbon dioxide in the atmosphere has changed in the past hundred years. Before the Industrial Revolution, carbon dioxide levels stayed nearly stable for thousands of years. Since human beings developed a fossil-fuel-based global economy and lifestyle, the amount of atmospheric carbon dioxide has increased dramatically. This increase means that less long-wavelength energy emitted from the Earth can escape to space. Many scientists believe this can lead to a gradual warming of the Earth, but others believe that different factors counteract this warming effect. For example, cloud cover reflects sunlight before it ever reaches the Earth, thus reducing the amount of sunlight that reaches the Earth's surface. Studying these processes is difficult, because they are complicated. Ocean color information provides one of the many tools scientists use to try to find what changes are occurring, and how they may affect us.

Activities: And Discussion Questions

1 There are areas of the ocean with relatively large concentrations of nutrients that animals and plants use as food substances. In these areas you see a lot of phytoplankton (the plant portion of plankton), especially in the spring. Why do some areas have greater amounts of phyto-plankton? Where would be the best place for deep-sea fishing?

2 If a zooplankton, a very small animal type of plankton, eats a phytoplankton, generally speaking, what happens to the zooplankton and the carbon that remained in the phytoplankton?

3 What is an example of the lowest level of the "food chain" on land?

4 Scientists use two types of satellites to study the environment. A **geostationary** satellite remains above the same spot on the Earth's equator from an altitude of about 22,500 miles, and can "see" an entire hemisphere all the time. A **polar-orbiting** satellite travels in a circular orbit, passing above the North and South Poles while the Earth rotates beneath it. This type of satellite can "see" details as small as a mile or less. Which of these satellites probably would be better for our ocean color instrument? Would one prove better than the other to track hurricanes and other large weather systems?

5 How do the atmosphere and the ocean interact?

6 How could global warming affect sea levels? Why is global warming important?

7 Where do plankton grow?

8 Make a greenhouse.

Materials needed:

- Two cardboard shoe boxes
- Clear plastic wrap
- Two regular "weather type" thermometers
- Desk light with 75 watt or larger bulb.

Procedure:

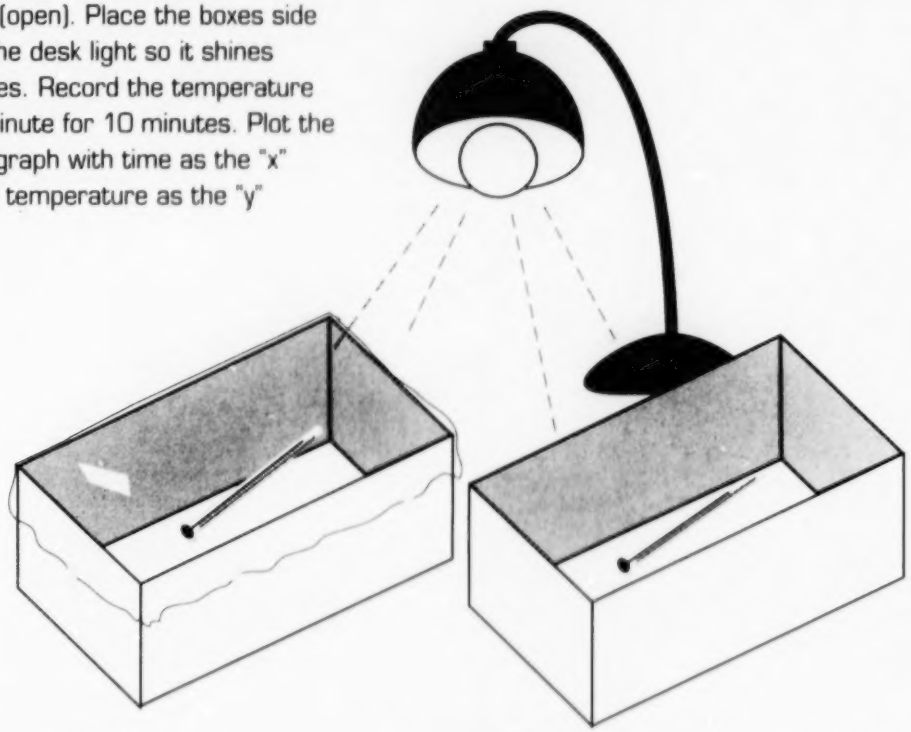
Place some paper towels loosely in the bottom of each shoe box, then lay the thermometer on the towels. Cover the open top of one box with plastic wrap, taped to the side of the box; leave the other box with the top off (open). Place the boxes side by side, and move the desk light so it shines evenly into both boxes. Record the temperature in each box every minute for 10 minutes. Plot the temperatures on a graph with time as the "x" (horizontal) axis and temperature as the "y" (vertical) axis.

Analysis:

Discuss the differences you see in the observed temperatures in the two boxes, and why this is happening.

Variation:

Try replacing the paper towels in each box with black paper. Repeat the experiment. What differences do you note?



NOTE: The information and activities in this guide are related to the poster, The Living Ocean (WAL-145, February 1994). The poster is available at NASA Teacher Resource Centers.

Answers

1. When wind-driven surface currents carry water away from continents, an upwelling of deep ocean water occurs. These cold waters have high concentrations of nutrients, leading to phytoplankton growth and creating a highly productive fishing area. Ocean plants live within 200 meters from the surface where there is sunlight.

2. Most zooplankton migrate to the surface at night to feed on phytoplankton, and then sink to greater depths during the day. When zooplankton die, they carry carbon with them as they sink to the bottom of the ocean.

3. Plants and bacteria are at the bottom of the food chain. Animals that eat grass, such as sheep, belong to higher food web levels.

4. A polar-orbiting satellite potentially can "see" everywhere in the world in about two days, and its orbit is low enough so that it can detect smaller details than a geostationary satellite. It will pass over a certain area once daily at the same time of day, which is important for instruments that use sun illumination for measurements of ocean color or land vegetation. A geostationary orbit can view almost an entire hemisphere at the same time, is able to track hurricanes and weather systems by making measurements every half hour or so, and also is used for meteorological purposes.

5. Differences in the heating and cooling rates of land and ocean affect air circulation. Land and water temperatures rise and fall at different rates because land absorbs and loses heat faster than water does. During the day, hot air rises and is replaced by cooler air. This small-scale circulation is called a sea breeze, and usually starts three or four hours after sunrise, reaching its peak by early afternoon. At night, the land is cooler than the water because the land has given up its heat to the atmosphere. The cool air flows over the warmer water and rises as it is warmed. This circulation is called a land breeze, and usually starts to form in the late evening. It reaches its peak intensity near sunrise.

6. Global warming may cause sea levels to rise by several mechanisms. Temperature increases may cause some of the ice in the polar regions to melt, which would raise sea levels. Higher water temperatures also may cause the oceans to expand. This expansion would cause a sea-level rise. Scientists are studying how global warming would affect sea levels, because a substantial rise in the sea level may flood coastal cities and other low-lying areas.

7. Plankton (microscopic drifting plants and animals) live near the ocean surface where there is sunlight. Satellites will see changes in the color of water that indicates growth of ocean plants.